Enhanced Networks Operations Using the X Window System

Irving Linares

NASA Goddard Space Flight Center
Network Control Systems Branch
Greenbelt, MD 20771

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Summary

We propose an X Window Graphical User's Interface (GUI) which is tailored to the operations of the NASA Goddard Space Flight Center's Network Control Center (NCC), the NASA Ground Terminal (NGT), the White Sands Ground Terminal (WSGT) and the Second Tracking and Data Relay Satellite System (TDRSS) Ground Terminal (STGT). The proposed GUI can also be easily extended to other Ground Network (GN) Tracking Stations due to its standardized nature.

1 Introduction

Currently, the operators of the various heterogeneous computer systems at the NCC, NGT, WSGT and the future STGT need to monitor and control the computer systems under their responsibility using dedicated terminals for each system. Some of these terminals are just ASCII interfaces which provide no graphical capabilities, thus they can not support intuitive user-friendly Graphical User Interfaces. This makes performance data analysis unnecessarily harder than what it should be. Some operators even have to alternate between different locations within the control room to perform status and command operations.

With the increased availability and affordability of open networking among major workstation vendors, it is a sensible solution to integrate multiple status and control

terminals into a reduced number of terminals with multiple windows. The X Window System[1] was just designed to meet this requirement. A multiple window display offers a much broader centralized picture of the overall system status while it could simultaneously improve the efficiency of the control center operations. It can also provide an intuitive user-friendly graphical model of the system interfaces that can be designed to minimize entry errors.

Many other Commercial-Off-The-Shelf and NASA custom-developed services can be easily incorporated into the basic X Window System to dramatically improve the *intercenter* and *intracenter* Human-Computer and Operator-Operator Interfaces once the basic infrastructure is in place[2]. These services, which could be encompassed by the *multimedia* term include but are not limited to: FAX, NASA Select Television, enhanced electronic mail containing text, graphics, animated sequences, images and audio), Video Teleconferencing, Space Tracking and Data Network (STDN) Electronic Library with hyperlinks to engineering drawings and technical manuals, CD-ROM interactive training, what you see is what you get (WYSIWYG) word processing, still image capture and display, Logistics, and Facilities Automation among others.

A well designed distributed system should provide fast real-time response, high availability and reliability, security, robustness, fast prototyping, openness in terms of multivendor support and transparent structured transitioning into operational systems. The UNIX Operating System in conjunction with the X Window System can satisfy all of the above requirements. NASA can advantageously use the X Window System to integrate already developed standalone applications to provide all the aforementioned services in a cost-efficient dependable way while still satisfying all the operational and real-time constraints of a control center environmet. The X Window System application proposed in this paper, with its high degree of modularity, multi-vendor compatibility, flexibility and intrinsic expandability should provide a long lasting investment to safely launch us into the next century control center.

2 Proposed System Architecture

The proposed baseline system standardizes on well accepted International and *de-facto* client/server models. The basic building blocks are the Open System Interconnection (OSI) Seven-layer Reference Model, the Transmission Control Protocol/Internet Protocol (TCP/IP), the Integrated Services Digital Network (ISDN) Protocol and the MIT X Window X11R5 (or later) System. Additionally it is suggested to adopt the Motif Window Manager (mwm) and the UNIX Operating System which are supported by all the manufacturers under the current NASA Scientific and Engineering Workstation Procurement (SEWP) contract[3]. Another requirement is RGB video monitors and RGB video switching. All the displays under the SEWP also are compliant with RGB signaling. A typical configuration is shown in Figure 1.

We specifically propose to separate video and voice from the data on the network to further enhance the robustness during possible emergencies and to prevent LAN overloading under normal operating conditions. In the future, if the Fiber Distributed Data Interface (FDDI) becomes commonplace, we *may* consider mixing voice, data and video on the same network.

3 Functional Requirements

We propose that minimally, an *administrative* workstation should have access to the following services:

- Technical Information Program (TIP)
- Automated Logistic System (ALS)
- Enhanced Logistics Information Management Systems (E-LIMS)
- Interactive Multi-Media/Computer Based Training (IMM/CBT)

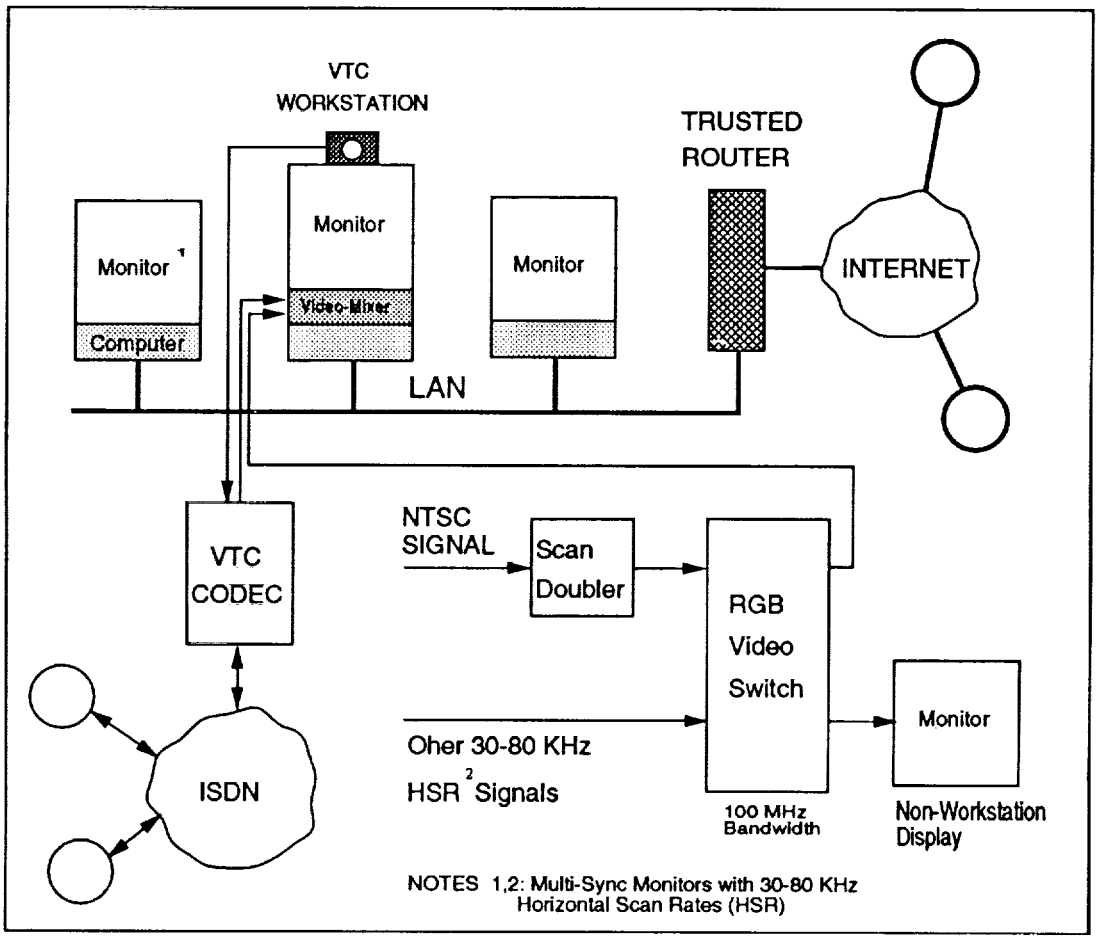

Figure 1: Typical system configuration.

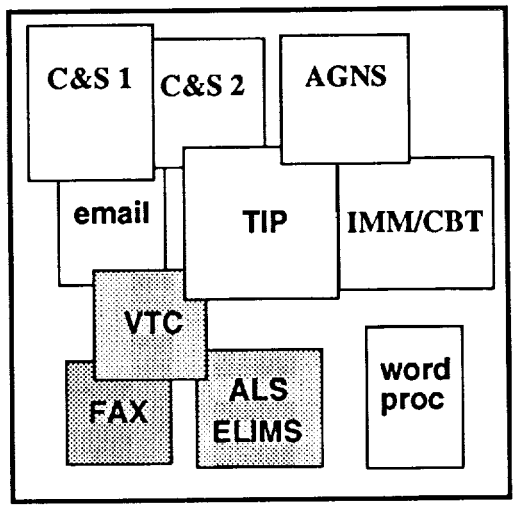

Figure 2: Depiction of some X Window services that could be made available to each workstation. Legend: C&S = Control & Status, email = electronic mail, VTC = Video Tele-Conferencing.

- Video Teleconferencing (VTC)
- Electronic Mail (email)
- File Transfer Protocol (ftp)
- Remote login (telnet)
- WYSIWYG Word Processing
- Weather Reports

An *operations* console should have all the above services plus access to

- Several Control and Status GUIs as dictated by the position responsibilities
- Facilities Automation System (FAS)
- Automated Ground Network System (AGNS)

TIP is a Mission Operations and Data Systems Directorate - Code 500 Level I Project. It was conceived as a comprehensive approach to unifying the technical information systems across Code 500. TIP is building an inter-organizational information infrastructure whose operations concept is based on four tenets: information capture at the point of origin, interoperability of tools, reusability of technical information products and electronic connectivity. TIP information infrastructure functions span the four domains of technical information processing: creation/revision, distribution, use and management. The reuse of contract data deliverables, especially technical information manuals, engineering drawings and their associated computer files, is a major goal of TIP and results in significant cost savings. In addition to creativity standards and specifications, TIP is providing integrated services such as text and graphics scanning, networked printers and plotters, engineering CAD symbols libraries, electronic publishing, a master index of documents and drawings, document number administration, and automated distribution.

The ALS modules will provide information regarding Customer Orders, Order Status, Asset Availability, Technical Information and hypertext Customer Service Handbook. A CD-ROM system is provided as a subscription service by Information Handling Services (IHS). Some of the products currently available are

1. IC/Discrete Parameter Database
2. Vendor Master Directory, full text OEM and Distributors Catalogs
3. NASA Documents
4. Department of Defense Standards and Specifications
5. GSA Source One
6. RECAL/Z (Resistors and Capacitors)

Both text and images are available for PC, Macintosh and UNIX platforms. Future plans call for the information to be delivered via LAN/WANs to autorized users.

E-LIMS will be the site-based portion of the Logistics Engineering Support System (LESS) that supports the information management needs of the site logistics activities. E-LIMS will maintain the Site Inventory Database (SIDB) and generate requisitions when predetermined resupply levels are reached (automatic resupply). E-LIMS will provide site personnel with the capability to query local inventory, issue items, place items into the inventory, and requisition items from the Logistics Support Depot (LSD). It will also enable the customer to query LSD-provided catalog systems (e.g., HAYSTACK or local CD-ROM database) as well as other stations' and LSD inventories. It will respond to inventory queries from other E-LIMS and the LSD. E-LIMS will be a PC-based client-server system of multiple, interconnected workstations at each site. It will provide a Graphical User Interface, mouse and incorporate automatic identification equipment (e.g., bar code) to facilitate the inventory control process. It runs under OS/2 and uses the DBM relational database management system. E-LIMS is currently under development and partial functionality exists. The first system will be installed at the White Sands Complex by the end of 1993.

IMM/CBT is provided by the Networks Training and Test Facility (NTTF). A prototype system running on a Mac Centris 650 equipped with a CD-ROM drive can provide audiovisual training ranging from introductory-level Networks system description (for example a TDRSS Orientation Course) to fully interactive testing, scoring and ranking on particular hardware such as the Command Data Formatter (CDF). A typical session shows scanned images of the system board-level components with whom the student can interact measuring signals, applying power, troubleshooting, etc. This approach can provide the required simulation based training leading to certification for mission critical systems which can not be made available for training.

ISDN-based *dial-up* Video Teleconferencing should be provided to selected positions such as station directors, network managers or mission controllers. VTC with its graphic and image capture capabilities is the obvious progression to the voice telephone and FAX. Additionally, NASA Select or any other RGB signal present at the location's TV switch could be selectively made available to authorized users as a *Picture-in-Picture* window. We propose to use INTERNET Electronic Mail which provides world-wide access to commercial, educational, scientific, military and government facilities. Its geographical coverage is much less restricted and it is far more friendly than our current NASAMAIL facilities. With INTERNET we also get fast file transfer service (ftp) and remote login capabilities.

Operation consoles can benefit from the above services while performing their required control and status functions. Two other systems, FAS and AGNS could physically decentralize while logically centralize Facilities and Operations.

FAS is composed of four subsystems including:

1. Computerized Maintenance Management System (CMMS)
2. Electronic Drawing Management System (EDMS)
3. Facilities Management Information System (FMIS)
4. Equipment Instrumentation System (EIS)

The CMMS will be used by station personnel to initiate and track work orders, manage preventive and predictive maintenance and for work planning and scheduling. The CMMS will electronically interface with the station logistics systems to determine the availability of parts required and for subsequent requisitions.

The EDMS will be used at GSFC, by support contractors and at each Network station. The EDMS will allow its users to review and plot selected copies of facility as-built drawings. The EDMS will also allow facility supervisors at each station

to annotate drawings in conjunction with a Facility Change Request (FCR). The NMOS support contractor will maintain a master set of as-built drawings and will make distribution of duplicate raster formatted copies (electronically) to GSFC and to each respective station as necessary.

The FMIS will be used by facility personnel at each Network station and by GSFC personnel to track special facility events, assist in facility project planning and handle all phases of FCR processing (EDMS will provide access to related drawings). The FMIS will also be used to perform budgetary analysis and forecasting and provide advanced reporting capabilities.

The EIS will be used at each Network station to monitor and control facility support equipment such as power distribution, air conditioning, antennas, fuel systems, station engine/generator systems, fire detection systems, etc. The EIS will also monitor environmental parameters (inside and outside) such as temperature, pressure, humidity and air quality. A significant feature of the EIS will be its ability to track and provide early problem detection of critical support equipment. This will permit advanced repair and correction (before failure) thereby avoiding a potential station down time.

The intent of the AGNS is to reduce station life cycle costs. Automated Monitoring and Control (M&C) is one of the key strategies proposed for achieving that goal. Other strategies include the use of Commercial Off-the-Shelf equipment in preference to custom-developed equipment, consistent application of standards to improve interoperability and the maintenance of configuration information in easily modified database tables.

AGNS uses commercial workstations (SUN Sparc) for operator interfaces, commercial control processors (VME computers) for real-time equipment interfaces and commercial M&C software. Development engineers define the behavior of all interfaces between the real-time computers and the equipment being controlled using

standard database tools (dBase IV) and draw display screens using software that mimics the behavior of typical computer drawing programs.

The workstations communicate with real-time computers using Ethernet and TCP/IP. Separating real-time processing responsibilities (done in the real-time computers) from the display functions (done at the workstations) permits us to place operators and their workstations at any location that can be reached via local or wide area network. Only the real-time computers need to be co-located with the equipment being monitored or controlled.

4 Security Issues

There is the need to provide National Resource Protection and Computer Security for systems connected to the INTERNET. The usual way of addressing this problem is by using trusted bridges and routers. A commercial system, the *FIREWALL* Computer[4] has been mentioned as a candidate to perform packet security filtering. This system provides some measure of isolation between the a LAN and INTERNET. The FIREWALL system controls and monitors all incoming and outgoing traffic but only allows connection of those hosts and services which are cleared to be interconnected. Another possibility is the Compartmented Mode Workstation (CMW)[5]. This System is rated as B1+. UNIX machines such as the SUN can be minimally configured as C2 systems by themselves without using any external devices[6].

5 Implementation Example

We recently demonstrated a prototype "Multimedia" system for the NASA Station Management Conference. The demonstration included a subset of the most likely services required in future NASA Control Center and Station administrative consoles. Some of the services shown were the Technical Information Program electronic

library, the Automated Logistics System showing scanned commercial catalogs directly from CD-ROM, an Interactive Multimedia Computer Based Training audio-visual application, ISDN based Video Teleconference and several other utilities such as live television in a window, a typical Control Center Graphical User's Interface simulating Space Network message flow, the Moving Picture Expert Group (MPEG) video-compression standard, FAX, Word-Processing utilities, and the latest weather including cloud cover and ground observed winds and temperatures. These utilities were complemented with email and electronic talk and were seamlessly integrated and concurrently displayed on a single screen using the X Window System.

The Local Area Network used for the demonstration contained a typical heterogeneous mixture of machines including 486 PCs, Macs and SUN SPARCstations aimed at showing the concept of system interoperability and compatibility. Each host with its appropriate TCP/IP driver was networked using *thinnet* (10_2) Ethernet. The PCs were running DOS 6.0 and Microsoft Windows Version 3.0 and the Macintoshes were running Mac OS 7.0. The SUNs were running SunOS Release 4.1.1. For the PCs we used DESQView/X 486 X-Server Software. This package also provides a limited DOS and Microsoft Windows X-client capabilities. For the Macintosh we used Planet-X client software and the Macintosh eXodus X-server.

6 Conclusion

Based on the very positive feedback and acceptance of the "Multimedia" workstation concept shown at the NASA Station Management Conference it is recommended that INTERNET and the X Window System be used by the NASA Networks Division to further solidify a distributed open computing environment among our stations.

Future availability of the LAN/WAN interconnection through the AGNS-provided INTERNET will integrate the Merritt Island and Bermuda Stations with the God-

dard Center Network Environment (CNE). There is also active interest in providing INTERNET service to other Space Network (SN) locations. We need to assess any security risks and weight the cost/benefit tradeoffs involved in making this decision prior to connecting these sites to the INTERNET. A local administrative network at an SN site does not necessarily imply an INTERNET connection, however the site could immediately benefit from resource sharing and vendor interoperability if a TCP/IP LAN solution is used.

The open nature of the X Window System with its high degree of vendor independence, modularity and expandability not only will improve the operations at NASA control centers and stations but will signify a radical departure from proprietary and custom architectures. As a net result, an implementation based on the X Window System could imply lower life cost cycles and a more reliable distributed computing environment. An X Window System implementation will also emphasize NASA's commitment to Total Quality Management.

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